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TOWARD A RATIONALE FOR A NATIONAL SPACE PROGRAM (U)

An Outline of Important Questions

July 22, 1959

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July 22, 1959

R-349-NASA

The RAND Corporation
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FOREWORD

This report to the National Aeronautics and Space Administration is designed to serve as background for a systematic study to be undertaken under the auspices of the NASA. The objective of this latter study is the construction of a rationale or policy-planning basis for a national space program.

The broad problem to be considered is, in the words of the Administrator of NASA:

> "To identify national objectives to be served by a program of non-military space activities, to suggest the magnitude and scope of the program required to attain those objectives, and to determine the balance of emphasis to be placed on various phases of the program in both the short and long term future."

. . . From a memorandum by T. Keith Glennan, June 19, 1959, "On the Need for a Study To Develop a Supportable Position on Rate and Scale in Space Research."

CONTENTS

I. INTRODUCTION

NATIONAL OBJECTIVES

The non-military space program of the United States is predicated on five objectives:

1. To gain stature for the nation in the general struggle with world communism.
2. To contribute relevant technical knowledge and services to the national defense effort.
3. To advance science and technology generally.
4. To develop space systems for public welfare and commercial applications.
5. To cooperate with other nations in the use of space systems for peaceful purposes.

These objectives in many ways are mutually supporting.

SIZE AND SCOPE OF THE PROGRAM

To determine the dimensions of a suitable non-military program requires first an appraisal of the entire national space effort, including of course the military missile and space program. Moreover, it requires an appreciation of the way in which space activities, military and non-military, are related. The feature that gives unity to all space activities, despite their diverse objectives, is the fact that they all rely upon a common technology and, frequently, upon identical equipments and facilities. This interdependence must be recognized when physical requirements for either type of activity are considered.

THE PROPER EMPHASIS

The emphasis that should be placed on various phases of the program, in both the near and distant future, must grow out of an appraisal of our existing and potential capacities for space activities, and a reëxamination of our national motives.

A RATIONALE FOR THE PROGRAM

Three broad questions seem important in working toward a rationale for the national space program:

1. (a) What is the value of world leadership in space science and technology?

   (b) What will be the price of equaling and surpassing the achievements of the Soviet Union?

2. How should the non-military space program relate to the total national space effort, including military missile and space activities?

3. How may the public interest be served by programs in space science, by international cooperation in space activities, and by public-service or commercial applications of space technology?

Other, more specific questions formulated in this report appear inevitably to lead back to these three; in consequence, these broad questions may be viewed as a point of departure for the discussion that follows.

SOME TENTATIVE GUIDELINES

The discussion presented in this report can help in reaching the ultimate decisions of policy on the hard questions of over-all level and rate of the national space effort; however, no formula is suggested for automatically assigning relative weights to such factors as the costs of possible space activities, the value of potential strategic, technical, or economic gains,

the risks of military and political losses, and the comparative worth of competing demands on available resources.

The guidelines listed below, then, in themselves do not comprise the rationale for a program. Rather, taken with the specific questions set forth in ensuing sections of the report, they may suggest to those charged with responsibility for policy decision logical courses of inquiry to follow in attacking the over-all problem.

- World leadership in space science and technology can be a potent political and psychological weapon in the struggle with communism. Much of its value as a cold-war weapon could be lost, however, if we do not act in the relatively near future; and regaining leadership may well prove increasingly difficult as time goes on.
- The minimum price of a substantial space effort depends largely upon the costs of vehicles and facilities; therefore, cost efficiency considerations indicate that vehicles and facilities which can serve interchangeably in military, scientific, public service, and other applications would offer large rewards.
- The rate of progress in space programs will be heavily influenced by national policy on the military and non-military parts of the program; e.g., whether the policy aims at mutual reinforcement of these two parts instead of the non-interference which has prevailed in the past.
- To obtain adequate public support of the relevant basic sciences is vital for maximum rate of progress in space technology. Since space activities involve nearly all of the sciences, public support of a space program amounts to support of science in general.
- A number of ways exist for the U.S. to take the initiative in international cooperation o[redacted]ies, including use of the

opportunities offered by world-wide networks for observation, tracking, communication, and recovery. Possibilities for cooperation may exist in monitoring nuclear tests, in using satellites for "open skies" observation, and in launching spacecraft from IRBM missile sites already established. (Similar opportunities are of course open to the Soviet Union.) International negotiations on space activities, in the United Nations and elsewhere, will bring increasing demands for participation in formal meetings and for implementation of agreements.

- o Minimum expenditures in international activities appear to depend on the need for a world-wide ground-station network. Some international cooperation is clearly indicated so that the scientific resources of the free world may be used. The conduct of high-cost international activities will doubtless depend upon expectations of political gains.
- o The rate of effort on public service or commercial application will depend upon public and industrial interest in exploring the possibilities with public and private funds, upon the degree to which pertinent military developments can be carried over to civil uses, and upon the outcome of current studies of the economic and competitive aspects of such systems.

The degree to which the above guidelines are applied must be determined by those charged with the ultimate responsibility for decision. The following discussion includes a more extensive consideration of the major issues and raises questions for which satisfactory answers appear to be needed; it thus moves toward developing the "rationale" for a national space program.

II. WORTH AND PRICE OF WORLD LEADERSHIP

POLITICAL IMPLICATIONS OF SPACE ACTIVITIES

In late 1957 and early 1958 the United States was caught lagging in what suddenly was thought of as a "space race," wherein over-all scientific standing was confused by the shifting criteria of "national prestige." Regardless of their ultimate validity, these criteria and their application are important politically, both on a national and an international scale.

It is important to examine the decisions to be made on pursuing, or abandoning, the contest for world leadership in space activities, because all courses of action in this matter are costly in one way or another: a vigorous competitive program will have a high dollar cost; an inadequate competitive program may result in unacceptable political losses.

The ensuing discussion deals in the main with the relative standing of the U.S. and the U.S.S.R. in space technology, and with the consequences of various courses of action that would affect this standing. Many other activities of course contribute to the relative standing of the U.S. and the U.S.S.R. in the eyes of the many peoples whose opinions we must consider; but the spectacular popular appeal of space achievements, their considerable military implications, and the political use that has already been made of them by the Soviets place high political worth on this field of endeavor.

By employing a powerful propaganda apparatus behind an effective screen of secrecy, Soviet tactics have gained a large measure of credibility for the regime's military claims while effectively preserving its pose of peaceableness. The image of the Soviet space program that has been impressed upon much of the world is one in which science governs and political considerations do not intrude; space bodies are launched only when science will benefit, and the

launchings are invariably successful. In contrast, the image of the American program that Soviet propaganda fosters with some success is one of frenetic striving to catch up with the U.S.S.R.--a hopeless race in which science is subjected to the arbitrary commands of aggressive politicians and generals, and failure follows upon failure.

One basic Soviet propaganda tactic is employed to achieve these effects: plans for future Soviet space activities are characterized as wholly scientific and devoted to peaceful progress, while the military implications of past Soviet space successes are emphasized at certain times in warnings and declarations directed at selected countries and audiences. In contrast, plans for future U.S. space activities are depicted by the Soviets as serving military objectives, while past U.S. space successes are minimized and deprived of military significance. The Soviet Union thus has been exploiting the prestige gained through its augmented military strength and scientific achievements to intimidate lesser nations in the free world--and if possible the United States itself--without arousing the apprehensions of neutralists and pacifists.

The Soviet leaders seem to have exploited each successful space launching for political ends. In some cases these ends may have influenced the timing, or perhaps even the decision to attempt a particular space shot. For example, just a few days after Sputnik II was launched, leaders of the world communist movement assembled in Moscow to celebrate the 40th anniversary of the Bolshevik Revolution. The launching provided grounds for enthusiasm for the assembled communist leaders, who met at a time when the effects of the Hungarian rebellion, and of Polish insubordination, were still being felt in the communist world. Moreover, it enabled Khrushchev to boast of Soviet strength at a time when the world was inclined to speculate that Soviet military power had been weakened by the purge of Zhukov.

Apart from its use as an element in Soviet grand strategy, the space program has also proved very useful in domestic politics, particularly as a means whereby Khrushchev has consolidated his position as dictator by identifying himself with the Soviet space and missile programs in order to derive credit from their successes.

Whatever Khrushchev's role in the development of Soviet space and missile technology, there can be no question that he has been the principal agent of its exploitation for political ends. Inasmuch as he has consolidated his position as dictator, Khrushchev's penchant for this instrument suggests that it will play an increasing role in Soviet grand strategy.

An important feature of the space competition is the impact it may have on nations other than the chief competitors. If a third country interprets Soviet space leadership to mean the triumph of socialist over capitalist science and industry, the interpretation will color that country's expectations about the outcome of the cold war, its appraisal of the moral as well as the economic viability of the two systems, and perhaps its assessment of their ultimate military strength. These estimates may lead the third country to act in such a way as to help validate them; for example, by turning to the Soviet Union for technical assistance and by sending its students there for technical and scientific training.

> <u>Question:</u> Assuming that the U.S. can raise foreign estimates of our future national strength by restoring the fact and the image of U.S. technical equality (if not superiority), how can it achieve this restoration without undermining belief in our peaceful intentions?

The Soviet government has played up its space achievements at home without restraint, so that astronautical ascendency is one of the outstanding facts of Soviet life and has been used as a prime illustration of the inherent

superiority of the government and of communism in general. This environment creates an opportunity to exploit the situation by means of impressive accomplishments by the United States. Such accomplishments could have a substantial impact on the Soviet population, and materially influence their views of the competing political systems.

<u>Question</u>: Within our present and programmed capabilities, how can the U.S. best capitalize on this opportunity?

Aiming at successes in the near future may have a higher political payoff than aiming at developments in the more distant future. On several grounds, it appears to be important to keep from falling farther behind the Soviet Union in space technology. The effort required by the Soviets to maintain leadership over the U.S. could increase sharply if they were driven to special developments beyond those directly available in their military program. While quickly carrying competition to this level would require substantial increments in the U.S. budget in the near future, these increments might be difficult or painful for the U.S.S.R. to match. A decade or so hence, however, it may not be difficult for them to match our budget increases, and their growth may already be an established fact. If little is done by the United States now, the U.S.S.R. may later be able to match and offset almost any actions taken by the U.S.

Any detailed consideration of the economic feasibility to the U.S.S.R. of a heavy, sustained effort in space must proceed with the realization that the purchasing power of money in this activity in the Soviet Union is likely to be high in relation to its purchasing power in the economy as a whole, since expenditures for space activity may enjoy the artifically low price levels associated with Soviet military procurement.

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COMPARATIVE U.S. CAPABILITY

The U.S. still has not brought its gross capabilities up to those displayed by the U.S.S.R. As a rough comparison, the Atlas satellite launched on December 18, 1958, carried a payload weighing about the same as that of Sputnik I launched on October 4, 1957, that is, less than 200 pounds. No U.S. space vehicles yet launched can be classed with the subsequent Soviet vehicles, which carried payloads weighing from 1000 to 3000 pounds.

The first test of a Soviet ICBM took place less than two years ago. It is, therefore, reasonable to suppose that development of these vehicles is still actively going forward and that the space capabilities available to the U.S.S.R. through exploitation of this development will grow markedly for quite some time.

The rocket performance displayed by launching Sputnik III on May 15, 1958, and again by Lunik/Mechta on January 2, 1959, will not be realized in the U.S. program until successful flight of the Atlas/Hustler rocket (ARPA/Air Force Project WS-117L), not expected to occur before late 1959 or early 1960, a system which is presently planned solely for military employment.

Question: Should plans be made for non-military employment of WS-117L equipment?

The first point in the present program at which the U.S. can expect to somewhat exceed the capability already demonstrated by Sputnik III is successful flight of the Atlas/Vega, not now expected before late 1960. The first opportunity to exceed the payload of Sputnik III by a substantial amount will depend upon successful flight of the Atlas/Centaur, not now expected before 1961, or a complete Saturn vehicle some time later.

Question: Should plans be made to acce[redacted]ment of Atlas/Vega, Atlas/Centaur[redacted]

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These comparisons, based on payload weight, are not complete, since the perfection of auxiliary equipment is also important, and the use made of the payload capacity is a vital consideration. Many useful things can and will be done with smaller vehicles. However, payload weight is a very useful index because it sets the scale of possible activities--things can be done within a payload of 1000 pounds that cannot be done in 100 pounds or even in 10 packages of 100 pounds each. This factor is particularly relevant for manned flight, where about a ton of payload is required as a minimum.

System reliability is also a very important parameter since it sets the politically vital ratio of successes to failures. Achievement of high reliability is generally associated with thorough development and testing, and is not ordinarily displayed by a program involving a few each of many different items.

COSTS OF LEADERSHIP

The price of capturing and maintaining leadership will be determined by the cost of those programs likely to lead to a general view that the United States is "ahead" in astronautics; this price may be partly offset by the value accruing to other objectives from these programs. There are no formal rules to this curious game, but certain observations seem valid:

1. Being "ahead" will, for some considerable time, rest heavily on "firsts" (not stunts, but substantial accomplishments). Therefore, the development and other costs leading up to a new capability might fairly be charged entirely, or in part, to the leadership objective; a high fraction of the cost of subsequent sustained use of that capability, however, would have to be charged to some other objective.

2. In this new field there are many possible "firsts," but three may be judged to be of particular early importance:

a. Successful orbiting and return of a man.

b. Successful photography, of reconnaissance quality, from a satellite.

c. Successful landing of a working payload on the moon.

3. Payload size is an important index for assessing relative standing because it is essentially a forecasting parameter: possession of a larger payload capability implies better prospects for scoring significant "firsts" or other desirable accomplishments.

4. For some time to come, the dollar cost to the U.S. of the competition for leadership will be set by costs of development and initial operation of the vehicles and associated facilities required to maintain an adequate growth of payload capability and acceptable levels of reliability.

5. The vehicle development program must be supplemented by vigorous, but less costly, efforts to provide payload assemblies (scientific instruments, etc.) that will demonstrate useful employment of the vehicle. The objectives served by flight of these payload assemblies--scientific, military, public-service--will have to justify the cost of sustained use of the vehicles and facilities after the leadership potential has been exploited in initial operations.

6. If other objectives--scientific, military, public-service--adequately justify the cost of achieving capabilities that enable successful competition, then the price of leadership is slight. The Soviets can evidently enjoy "leadership" at very little apparent cost so long as the capabilities acquired directly from the military missile program are adequate.

In principle, the cost of leadership could be assessed in the following way:

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1. Estimate the payload levels required to exceed materially the expected U.S.S.R. capabilities during the time period of interest.

2. Select the program actions that can best provide and use these required payload levels.

3. Estimate the fraction of the total program costs that can be fairly said to represent value to other national objectives.

4. Consider the remainder of the total program costs as chargeable to leadership.

Considering the magnitude of payload already demonstrated by the U.S.S.R., the problem of justifying a high fraction of program costs by other objectives may be severe. The operations that presently seem to imply actual requirements for large payloads are various military projects and the large-scale scientific activities, e.g., manned satellite laboratories, and lunar and planetary exploration.

> Question: Do present plans for space activities, military and non-military, place suitable emphasis on the objective of capturing leadership?

ARGUMENTS AGAINST THE "SPACE RACE"

One line of reasoning that should not be overlooked stems from an assumption that it is undesirable to attempt to overtake the Soviet Union in space achievements in time to give any appreciable payoffs, or that even if we could do it within several years, it is not worth the expenditure of several billion dollars and the resulting drain on the economy and resources involved.

Some arguments that have been heard in support of this thesis include:

- The whole history of Soviet astronautics indicates that Soviet activity has, for nearly a generation, been pursued with determination, with a singleness of purpose, and with consistent support; and

therefore that the Soviets are so far advanced that it is unsound to think of overtaking them at an early date.

- To support the kind of effort in space achievements needed even to draw abreast of the U.S.S.R. at some early date will require an annual expenditure of something like a billion dollars for several years, a substantial share of which could better be put on other activities, science for example.
- The real value (other than military) of satellite operations and other expensive space missions is in no way comparable to their very high costs.
- Even the cost of avoiding our falling farther behind could be more profitably and more soundly invested in other projects offering greater long-term benefits to the national economy and national security than satellites and spacecraft ventures. For example, in the other technological field represented by the National Aeronautics and Space Administration, would the commitment of one billion dollars per year, for three years, to the development of large high-speed transport aircraft offer more benefits to the national economy and the national defense, say five years hence, than a similar amount devoted to exploring the moon and planets? Or would not the application of several hundred million dollars per year to the support of basic science yield a greater probability of real returns to national economy and defense than a similar expenditure for some of the proposed space missions it could buy?

Examination of issues of this kind will probably only emphasize the basic question of how much, and at what rate, the nation can afford to support space developments, rather than disclose whether any given amount should be put

on space <u>or</u> on something else. It might also lead to the conclusion that the degree of support of any such activity should be considered on its own merits rather than judged against other nationally supportable activities contributing to similar broad national objectives, like advancing science and technology.

<u>Question</u>: To what extent would the saving resulting from a considerably reduced space program insure that other activities, which might be considered more meritorious, would benefit?

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III. RELATIONSHIP OF MILITARY AND NON-MILITARY PROGRAMS

One question pervades, even dominates, all phases of the problem of determining the direction, the rate, and the level of national effort to be put on space activities: the interrelationship of the civil and the military parts of the national program.

Public interest in satellite and space activities (beginning rather diffidently about 1954) in the United States was stimulated primarily by scientists through the agency of the National Academy of Sciences and related international activities, such as the International Geophysical Year. Military interest, which preceded public interest, concerned secret devices and applications; the scientific interest generally involved unclassified matters. As it developed, the national policy with respect to the relations between the military and non-military parts of the space program strove to keep the two parts separate. In short, the country seems to have followed, in all its major decisions, a philosophy of "non-interference" of the non-military with the military. Parenthetically, the Soviet Union clearly combined these two elements of their national program. The separation philosophy in the United States persisted through the Congressional consideration of the National Aeronautics and Space Act and resulted in a number of provisions in the Act for formal mechanisms to help discriminate the fields of responsibility for aeronautical and space activities to be exercised by the new agency and by the Department of Defense.

The intent of Congress in adopting a compromise wording is found in the Conference Report to accompany HR 12575, House of Representatives Report No. 2166, 85th Congress, second session.

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GOVERNING STATUTORY PROVISIONS

The National Aeronautics and Space Act of 1958 is the basic statute that established the National Aeronautics and Space Administration (NASA) and laid the groundwork for civilian-military direction of space activities. In its declaration of policy and purpose, Section 102, the Act contains a general expression of the allocation of responsibility between NASA and the Department of Defense, as well as a statement of certain objectives bearing on the question of civilian-military cooperation. Subsection 102(b) states that aeronautical and space activities--

> shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by the United States, except that activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by, the Department of Defense; . . .

Among the national objectives noted in Subsection 102(c), items (6) and (8) have special relevance to the question of civilian-military cooperation:

> (6) The making available to agencies directly concerned with national defense of discoveries that have military value or significance, and the furnishing by such agencies, to the civilian agency established to direct and control non-military aeronautical and space activities, of information as to discoveries which have value or significance to that agency; . . .

> (8) The most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment.

The Act also specifies certain machinery for formal coordination of aeronautical and space activities.

The fundamental allocation of responsibility for aeronautical and space activities within the Government is of course a compromise, which appears to

reflect several identifiable attitudes, beliefs, and policies. It may be useful to list some of those themes here briefly so as to bring out their interconnection and their unavoidable overlap.

1. There was a belief that the primary yield from the exploration of space would be scientific knowledge, and an assumption that governmental effort toward the acquisition of scientific knowledge should be primarily civilian because, so to speak, scientific knowledge was civilian in nature.

2. It was thought that the cooperation of the scientific community in the United States and abroad would be more successfully solicited by a civilian than by a military agency.

3. It was supposed that civilian direction would make the national space program look more "peaceful" abroad than military direction would.

4. A few persons looked on the public excitement evoked in the United States by the launching of the first Soviet satellites as affording an opportunity to establish a Department of Science in the Cabinet; for them, civilian control of space research and development was a minimum measure.

5. The operation of military space systems was acknowledged to be an exclusive concern of the military, to the extent that space systems could be identified as exclusively military.

6. It was believed that research and development for military space systems should predominantly, though not necessarily exclusively, be in the hands of the military. This belief was corroborated by or associated with considerations of special end-use requirements; special security (classification) requirements; established patterns of relationships with military end-users and with industrial contractors; and the momentum of established military programs and organization.

7. There may have been some dissatisfaction with the previous progress of ballistic and space technology under military guidance. Inconclusive disputes and recrimination over responsibility for past budget cuts and low program limits may have contributed to congressional support for a partial "fresh start."

8. There was considerable respect for the skills and achievement of the National Advisory Committee for Aeronautics (NACA), a civilian organization that had done much research of military importance and had cooperated with the military in its research programming. The decision to make NACA the nucleus of the new space organization--with major changes in authorized missions and in contracting authority--implied a preference for civilian control of space research and development.

9. The certainty of overlapping jurisdictions was recognized. Conflicts, it was supposed, would be resolved through formal coordinating machinery and in the last resort by the President.

10. Duplication of research and development effort was ritually condemned, but some voices were heard in favor of some duplication as increasing the probability of payoff. (The statutory formula cited above deprecates "unnecessary" duplication.)

The enactment of the National Aeronautics and Space Act did not abolish the problem or terminate the discussions growing out of the themes that have just been enumerated. Presumably they will be evaluated periodically in the light of developing experience in the administration of the Act and the operations of NASA under it.

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ORGANIZATIONAL DIVISION

Although the National Aeronautics and Space Act was enacted on July 29, 1958, NASA did not assume responsibility for non-military space programs until October 1, 1958. Before October 1, all U.S. space programs were administered by the Advanced Research Projects Agency (ARPA) in the Department of Defense. ARPA had been formed in February, 1958, as a transitional organization with authority of indefinite duration over military space programs and temporary authority over non-military space programs. Under the President's message to Congress of April 2, 1958, NACA and the Department of Defense were to review DOD programs to recommend which should be placed under the new civilian agency and which should be facilitated by cooperative arrangements between the new agency and DOD.

On October 1, 1958, by Executive Order 10783, the following programs were transferred to NASA:

1. Project Vanguard, with more than 160 scientists and technologists of the Naval Research Laboratory.

2. Five space probes which had been under the direction of ARPA.

3. Three satellite projects: 12- and 100-ft-diameter inflatable spheres and a cosmic ray experiment.

4. A number of ARPA and Air Force engine development research programs, including their work on nuclear and fluorine rocket engines and study and development of a 1.5-million-pound-thrust single-chamber rocket engine.

In December, 1958, by Executive Order 10793, the President transferred from the Department of the Army to NASA the functions and facilities of the Jet Propulsion Laboratory, operated by the California Institute of Technology under contract. At the same time an agreement between NASA and the Army provided for the Army Ballistic Missile Agency at Huntsville, Alabama, to carry out certain NASA projects.

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Thus at present different space programs exhibit several different types of organizational arrangements:

1. Exclusive NASA management, e.g., cloud-cover surveillance, lunar probes.

2. Exclusive DOD management, e.g., satellite-borne advanced reconnaissance development, ballistic missile defense.

3. NASA management with ARPA support, e.g., Project Mercury (the manned satellite program).

4. Parallel NASA-ARPA research and development, e.g., NASA single-chamber engine, 1.5-million-pounds thrust; ARPA, clustered booster.

5. Combined operation, e.g., certain functions in management and operation of tracking facilities.

6. Separate decision with interagency clearance, e.g., financial support of certain basic research done outside government.

STATUTORY MACHINERY FOR FORMAL COORDINATION

The National Aeronautics and Space Act set up two new bodies for interagency coordination: the National Aeronautics and Space Council and the Civilian-Military Liaison Committee.

The National Aeronautics and Space Council is composed of the President, the Secretaries of State and Defense, the Administrator of NASA, the Chairman of the AEC, an additional member from the Federal Government appointed by the President, and three eminent men from private life also appointed by the President. Its sole function is to advise the President in the discharge of his statutory duties under Subsection 201(e) of the Act, which are to:

> (1) survey all significant aeronautical and space activities, including the policies, plans, programs, and accomplishments of all agencies of the United States engaged in such activities;

[redacted]

(2) develop a comprehensive program of aeronautical and space activities to be conducted by agencies of the United States;

(3) designate and fix responsibility for the direction of major aeronautical and space activities;

(4) provide for effective cooperation between the National Aeronautics and Space Administration and the Department of Defense in all such activities, and specify which of such activities may be carried on concurrently by both such agencies notwithstanding the assignment of primary responsibility therefor to one or the other of such agencies; and

(5) resolve differences arising among departments and agencies of the United States with respect to aeronautical and space activities under this Act, including differences as to whether a particular project is an aeronautical and space activity.

The other coordinating body set up by the Act is the Civilian-Military Liaison Committee. It now consists of a Chairman appointed by the President, four representatives assigned by the Secretary of Defense respectively from the Department of Defense and the three military services, and four representatives assigned by the Administrator of NASA. The Act provides in Subsection 204(b) that NASA and DOD --

> through the Liaison Committee, shall advise and consult with each other on all matters within their respective jurisdictions relating to aeronautical and space activities and shall keep each other fully and currently informed with respect to such activities.

The original authority of the Civilian-Military Liaison Committee extended only to reporting conclusions, findings, and recommendations, including dissents and non-participation, to the Administrator of NASA and the Secretary of Defense. On July 1, 1959, NASA and the Department of Defense announced Presidential approval of a revised charter for the Committee increasing its authority. The major change in what was called the "CMLC Terms of Reference" directs the Committee and its chairman to deal with jurisdictional differences

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when they arise instead of permitting this mediatory action only upon the request of NASA or DOD.

OTHER COORDINATING MACHINERY

Non-statutory machinery has been devised for purposes of special coordination. For example, basic research at various outside institutions is supported independently by NASA, the National Science Foundation, the Office of Naval Research, the Office of Scientific Research in the Air Force, and the Office of Ordnance Research in the Army. The agencies concerned exchange lists of projects received, projects approved, and amounts of money granted. From time to time their representatives meet to coordinate their grants.

Another example of special-purpose coordination is provided by ground-support facilities. The operation of space vehicles requires several different systems; some of the facilities and personnel involved in these systems can be used in common (see Section VII of this document). In the fall of 1958 a coordinating committee from NASA and DOD drew up an interagency agreement, since signed by the Secretary of Defense and the Administrator of NASA, establishing a Space Flight Ground Facilities Board. Under the agreement, that Board is to review proposals for new ground instrumentation facilities where new tracking sites would be required or where a total Government investment of more than $250,000 is involved; to recommend the allocation of responsibility for funding, constructing, and operating those facilities; and to review annually the national budget for global tracking, data acquisition, and communications facilities. Each agency is to fund, construct, and manage facilities needed for the tracking, data acquisition, and communications support of its primary space missions, but certain common facilities are to be used "whenever feasible." Under specified conditions, site management may be divorced from the [redacted] and operation of instrumentation and

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communications equipment. Disagreements are to be reported to the Administrator of NASA and the Secretary of Defense.

An additional method of coordination is that which is imposed by the pressures of Congressional inquiry. Upon the receipt of separate requests from NASA and DOD for authorizing or appropriating legislation, Congressional committees have requested cross-waivers from the respective administrators, each certifying that the other agency's program did not unnecessarily duplicate his own. This practice has contributed to advance coordination between the agencies in anticipation of the inquiry.

AREAS OF COMPETITION AND COLLABORATION

When the techniques of military-civilian coordination of space activities were considered by Congress in its deliberations on what later became the National Aeronautics and Space Act of 1958, the emphasis was placed on formal mechanisms. The executive process of allocating responsibility for space activities, as one Congressional committee put it, had to be altered from a process of negotiation to a process of decision-making. The two organizations mainly concerned--NASA and DOD--were thought to have separable areas of primary responsibility, with a relatively small overlap. That overlap, or "grey area," was to be superintended by the coordinating machinery described above.

Up to now, the statutory prescriptions have been partially ineffective and partially untested. The Civilian-Military Liaison Committee seems, on the whole, to have been limited in its initial terms of reference, and bypassed by: (a) the creation of several ad hoc or special-purpose committees, of different degrees of formal structure and continuity, and (b) informal day-to-day accommodation at the working level. The Space Council seems to have been somewhat more active, but only as a registry for negotiated organizational compromises between d[redacted]rtmental heads; it appears to have served

[redacted]

neither as a Space Policy Board with power to impose broad managerial decisions, as the Senate at one point desired, nor as an advisory committee to the President and the Administrator of NASA in the sense envisaged by the House of Representatives.

<u>Questions:</u>

1. In the light of experience to date with the Policy Council and the Civilian-Military Liaison Committee, how can they fulfill their statutory responsibilities as defined by Congress?

2. Would the Council be more effective with a strong supporting secretariat or a subordinate preparatory body? (E.g., would the implementation of the permissive clauses of the Act providing for an executive secretary appointed by the President and confirmed by the Senate be desirable?)

3. Should the Civilian-Military Liaison Committee act as a subordinate or preparatory body to the Space Council?

4. Would the assignment of an active and experienced military officer as Chairman of CMLC (as provided in Sec. 204(d) of the Act) help harmonize the military and non-military parts of the program?

Relatively informal coordination is being practiced between NASA and DOD on such matters as management of ground-support or booster development; and these procedures are not formally codified by statutory amendment or even by regulation. Day-to-day contact between the scientists, engineers, and managerial staff of NASA and DOD, and growing familiarity with the nature of the R & D problem and the related management problems, should help to anticipate many incipient difficulties.

However, mutual accommodation of the sort mentioned here, whatever its merits, cannot be expected to resolve fundamental questions of space management. For example, the decision on the size of the fraction of the gross national product that should be devoted to governmental space activities

will not rest in the hands, however closely linked, of NASA and DOD alone. However, when they do take the initiative in proposing budget levels to the White House and ultimately to the Congress, the proposals should have more authority if NASA and DOD agree on them in advance.

Within the over-all budget for space activities, the division of funds and responsibility between NASA and DOD is, and will remain, partly outside the control of those agencies, because certain of the applicable policies will be decided by Congress or by higher executive authority. NASA and DOD, however, enter the decision-making process at several different stages: furnishing the necessary technical information, recommending over-all policy to the ultimate deciding bodies, applying and interpreting the necessarily general terms of the decisions, and recommending modifications (not excluding modifications in the size of the over-all budget for space activities). The combined weight of NASA and DOD action at all of those stages may be in practice nearly conclusive.

The "grey area" concept upon which Congress based its scheme of organizational accommodation may be administratively unsatisfying; but the line between military and non-military space activity cannot be clearly drawn on an objective basis in most cases. While military and non-military efforts may differ widely in intent, their physical requirements may not differ materially.

While there are serious disadvantages to many forms of duplication between NASA and DOD, these disadvantages do not necessarily extend to technical competition in research and development in the sense of competing programs toward the achievement of a common R & D goal. Simultaneous parallel efforts ("controlled duplication") may in fact ultimately mean a saving of time and money as compared with successive single attempts.

Therefore, space research and development activities of NASA and DOD are or can be made complementary and mutually supporting. For example:

1. One main area consists of the partial coordination of program planning through controlled duplication and what might equally well be termed "controlled non-duplication:" the agreed-on decision to abstain from research and development in a given area being covered by another agency. This would require adequate provision, not necessarily formal, for regular review and cross-communication of end-use needs.

> <u>Question:</u> What criteria should guide planning for "controlled duplication?"

2. An important special case of controlled non-duplication may be afforded by considerations of the structure of DOD planning. A very large part of research and development in DOD is keyed to the concept of integrated planning of weapons systems.

There is a certain amount of research, development and testing that NASA can be expected to perform in direct participation in established military activities by virtue of unique skills and facilities resting within NASA.

> <u>Question:</u> On the basis of NACA experience, and current indications of military activities, what level of direct support to DOD should be assumed in NASA planning?

In addition NASA can contribute materially to a forward-looking defense posture by engaging in research and development not associated with established weapon programs. The objective here should be simply to accumulate a large assortment of valid choices to explore in planning presently unknowable weapon system projects. This exploratory research and development effort may, therefore, frequently appear to be illogical.

> <u>Question:</u> What criteria are appropriate for setting the rate of expenditure for research and development not clearly associated with an end use?

[redacted]

3. DOD and NASA may buy or rent certain machinery, equipment, and ground-support facilities from one another instead of building them (in-house or contracted-out).

Maximum exploitation of equipments and facilities developed under prior military programs can contribute substantially to a more effective effort in the non-military program because many items of heavy cost are largely avoided: initial development, provision of testing and production facilities, volume testing to establish functioning and reliability. A cost advantage will also usually accrue to purchase of equipment items from a larger production program. The improved reliability to be expected in an item subject to more extensive testing is also of considerable importance both in cost and in the favorable public impact of fewer failures.

4. Certain types of intelligence-gathering, both political and technological, may be more effectively performed by a civilian than by a military agency, and vice versa. Both agencies may be appropriate customers from some or all of the data yielded by each. The conduct of, and public statements concerning, the non-military space effort--particularly with respect to the international competitive aspects--will be more effective if relevant intelligence data are available. On the other hand, diagnosis of data acquired from observation of open non-military space experiments by others is a source of intelligence information with military value; for example, U.S. observation of Sputniks has yielded inferences concerning Soviet weapons. Perhaps some U.S. space activities, non-military and military, could be planned with an eye to provoking Soviet "reaction" most likely to yield information bearing on particular intelligence needs. None of this has to do with deception, espionage, or distortion of international cooperation.

[redacted]

Besides the areas of competition and collaboration, or competitive collaboration, between DOD and NASA, certain functions, while not inherently devoid of military or strategic relevance, can be better performed by a civilian agency (whether NASA, other-governmental, or non-governmental). They include the general field of international cooperation in "peaceful" space activities; commercial, public-service, or other economic applications of space science; and the maintenance and supervision of a program of space activity appropriate to the needs of science.

Moreover, in the struggle for national prestige, the scientific, non-military nature of NASA would seem to give it several important advantages for certain activities. Publicity can be given to U.S. space activities if they are non-military and scientific ventures with less opportunity for communist propaganda attack. Dissemination of the results of space research can more easily be portrayed as intended for the benefit of all mankind. The participation of foreign scientists, including those of neutralist and even Soviet-bloc countries, is facilitated; this in itself contributes to the desired prestige objectives.

It would seem clear that the national rate of progress, as well as the rate and level of effort, depends critically upon a course of action that harmonizes both the military and non-military phases of our national program: in short, adherence to a policy of "mutual reinforcement" instead of the "non-interference" that seems to have prevailed. It would also seem clear from a careful perusal of the Act and the declaration of intent of the Congress that there is ample latitude for executive action within the present terms of the Act to go far in this direction. The major questions on jurisdiction that have arisen in the past and that surely will continue to arise in the future will be those that require agreement between the Department of

Defense and NASA (or in absence of agreement, decision by the President) on the interpretation of the degree to which certain activities may be "peculiar to or primarily associated with the development of weapon systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States)."

National achievements based on clearly defined "space" objectives will be difficult and expensive enough, even in the unlikely event that complete harmony and agreement on joint requirements between the military and non-military programs are attained. The cost in both time and money will be much greater unless effective means are employed to make the requirements of the two major elements of the national program complement and support each other. Those concerned with the problem, therefore, would do well to obtain views on it from the military departments as well as from NASA.

<u>Question:</u> How can joint development goals, satisfying both military and non-military needs, be established?

Assignment of responsibility to NASA or DOD for management of a given program aimed at joint development goals will probably depend upon such criteria as:

a. The relative importance or urgency attached to the military and non-military phases of the joint development goal.

b. Improved program efficiency to be expected through use of unique skills and facilities lying within the purview of one or the other of the federal establishments.

c. Improved program efficiency to be expected through close integration with another project that is clearly related to the prime interests of the military or non-military program.

d. Policy decision to favor military or non-military management of programs of essentially ambiguous character.

<u>Question</u>: Within these or other relevant criteria, what decisions are in order with respect to assigning management responsibility for current or planned parts of the national space program?

IV. SCIENCE PROGRAMS

One of the prime objectives of the national space program is the advancement of science. Since space activities have approached the frontiers of practically all of the sciences, public support of space activities will mean support of research in general.*

Maintenance of a vigorous and balanced scientific experimental program depends upon timely selection of desirable undertakings: proposed experiments must be explored in detail for their scientific merit, carefully related to existing physical theory, supported by adequate preliminary investigation in ground laboratories, and properly exploited in post-experiment assessment by both theoretical and laboratory studies, with results being expeditiously and widely disseminated.

> Question: Do present means for selecting space experiments adequately (Sec. 203(a)(2) of the Act) "arrange for participation by the scientific community in planning scientific measurements and observations to be made through use of aeronautical and space vehicles"?

In the short term, there is a backlog of experiments, largely generated by the International Geophysical Year satellite effort, yet to be carried through. At least to this extent, then, the physical capabilities for space flight still stand deficient. Construction of a solid future position in encouraging further experimental innovations will depend in part upon the dispatch with which this existing backlog is eliminated.

> Question: Is enough use being made of available military assets for earliest space experimenting?

Looking beyond this immediate problem into the era of large payloads (including men) and the ability to place these payloads in a wide variety

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*See the Space Handbook: Astronautics and Its Applications, Staff Report of the Select Committee on Astronautics and Space Exploration, 85th Congress, second session, pp. 209-216.

of space regions and on the surfaces of the Moon, Mars and Venus, one does not now discern any surplus of mature experiments. Rather, the impression is created that strenuous measures are in order to lay the foundations for an effective science program to exploit these truly enormous capabilities. It may be that very substantial programs of ground research will have to be initiated soon to develop a flow of productive questions to pace the growth of experimental opportunity.

> <u>Question:</u> How can a broad and vigorous research program be stimulated and supported--and at what rate of expenditure--to provide experiments compatible with the large vehicular capabilities already foreseeable?

In order to stimulate suggestions for worthy experiments from the widest possible range of scientific sources, there is need for a systematic way to keep planned space flight capabilities currently before the world scientific community, and thus to invite response. Such disclosure of possible or imminent capabilities must be carried out with due regard for the political impact of "promises made but not kept"; and the development program implied must be firm, and appear firm, with administrative and budgetary support that is strong and clear.

> <u>Question:</u> How should the planned program of space capabilities be conveyed to the scientific community?

It would be wrong to contribute to the impression that the scientist is being asked to justify the long-range program of heavy expenditures for engineering and operating necessities. He should not have to assert that the nation is buying a billion dollars per year of scientific knowledge. The responsibility for this large cost item must at this time rest on government and the people, with the experimental capacities accruing to it being viewed as a scientific opportunity to be used as effectively as possible.

<u>Question:</u> To what extent should the goals of the vehicle development program exceed the clear requirements of established scientific investigations?

Broadly speaking, scientific space exploration can be thought of in the following categories:

a. Free-space
b. Geophysical
c. Lunar
d. Planetary
e. Solar
f. Cosmological

Free-space exploration will consist of measuring and sampling the radiations and sparse matter in the interplanetary regions of the solar system. This activity will probably be characterized by fairly intense initial exploration to establish a general picture of radiations and matter, followed by a comparatively low rate of "patrol" activity to observe variations of environment with time. Free-space exploration will require instrument-carrying vehicles traversing the regions of interest.

Geophysical space research implies observations of the earth itself from an outside vantage point and measurement of the space environment in the general vicinity of the earth. The principal requirements for this research can be served by earth satellite vehicles and an observation station on the moon.

Lunar investigations can be done from the earth, from satellites around the moon itself and, most thoroughly, by men and instruments on the moon.

Planetary investigation is a general class of research within which study of the earth itself is one item. Exploration of the planets, therefore, can be generalized from exploration of the earth--the requirements include satellites about the subject planet and, for those planets with tolerable surface conditions, men and instruments on the subject planet.

Early investigation can take the form of improved telescopic observation from stations in earth satellites and on the moon.

Solar investigations combine the features of free-space exploration (measurement of radiations from the sun) and some features of planetary investigation (observation of the surface of the sun) from stations in earth satellites and on the moon.

Cosmological investigations are concerned with observation of the universe outside the solar system and study of the large-scale processes of nature. The requirements include free-space radiation measurements and observations from stations in earth satellites and on the moon.

These generalizations suggest classes of experimental mechanisms:

a. Instrumented free-space vehicles.

b. Vehicles carrying instruments and men into orbits about, or onto the surfaces of, the planets of the solar system.

c. Scientific stations in earth satellites.

d. Scientific station(s) on the moon.

Advancement of science through space-flight experiments will require expenditure of vehicles and incurring of ground operating costs.

> Question: What level of expenditure (for production of developed flight equipment and operation of ground facilities) should be devoted to flight of scientific instruments?

Advancement of science will also require research and evaluation, by theoretical and laboratory efforts, before and after accomplishment of any flight program.

> Question: What level of expenditure should be devoted to research and evaluation before and after any flight program?

<u>Question</u>: Should the research and development efforts of the non-military part of the national space program be strongly focused on one or a few large-scale goals such as a manned satellite laboratory, a station on the moon, or manned exploration of a planet? If so, at what pace should the program proceed?

In addition to use of space vehicles as tools for research in basic sciences, there is also clear need for flight experiments to advance engineering sciences on which space technology rests. In particular, it will be necessary to test and evaluate engineering materials and devices under space conditions in order to provide the basis for growth of national capabilities in astronautics. Examples are testing of environmental controls, structural materials, seals, lubricants, windows, surface finishes, power supplies, orientation controls, guidance equipment, communication devices, system reliability, etc.

<u>Question</u>: At what level should effort be applied to flight and ground activities for engineering research?

V. INTERNATIONAL COOPERATION IN SPACE ACTIVITIES

The public pronouncements of the U.S. Government on space matters consistently stress the importance of international cooperation in space activities, valued for its own sake as well as for reasons of national security and prestige. The National Aeronautics and Space Act of 1958 (Section 205) authorizes NASA to engage in a program of international cooperation; and NASA has established an Office of International Programs.

Among the opportunities for international cooperation in astronautics, the most readily available important opportunity is that for cooperative efforts between scientists of the U.S. and other countries in exchanging information, devising space experiments and mutually studying the resulting data. One step toward more direct cooperation might be to use U.S. vehicles to carry invited "guest payloads" belonging to foreign institutions.

Opportunities for important political benefits should exist in the need for a world-wide network of sites for tracking, observation, communication, and recovery. These sites need not be viewed simply as an inevitable financial burden on the U.S., but rather as internationally financed sites where close collaboration between American technicians and foreign nationals becomes practicable. Such cooperative efforts would amount to real participation of more than nominal extent by the countries selected. Considerable flexibility can be exercised in selecting the exact locations and the extent of individual facilities for best political advantage.

Launching facilities on foreign soil might also be considered. For example, the U.S. is now basing Intermediate Range Ballistic Missiles in Europe (the United Kingdom and Italy, at present)--the same kind of missiles currently being used for space-vehicle launchings. It may be possible to

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arrange a cooperative program with any of these countries to prepare space vehicles and launch them from these IRBM bases, the local military hardware being used as the basic equipment. In the United Kingdom, available assets for such an enterprise include trained Royal Air Force launching crews, firing-range facilities in Australia, U.K. rocket developments suitable for the necessary upper stages, and an active space science plan prepared under government auspices. The Italian government could, in a reasonable time, provide suitable equipment and personnel for a similar undertaking.

The kind of satellites now under development for military reconnaissance could, under suitable arrangements, contribute to the implementation of any "open-skies" plan associated with disarmament, arms control, or prevention of surprise attack.

In addition to satellites for observing installations on the earth's surface, need has been suggested for satellites to scan the skies and monitor agreements against testing of nuclear weapons in outer space. These satellites may also have to be supplemented with vehicles in orbit around the sun.

In considering the various possibilities for international cooperation, it should be borne in mind that the same possibilities are open to the U.S.S.R. Using observation sites as an excuse to place Soviet technicians on foreign soil would be entirely consonant with standard Soviet practices. The launching of a satellite from Red China, for example, albeit with Soviet equipment, would have quite an impact on world opinion.

> <u>Question:</u> Should the United States take the initiative in joint international support and collective effort?

Programs of cooperation between U.S. and foreign scientists may provide precedents for successful joint work that could carry over into inspection,

control, and limitation systems for the regulation of certain space activities in the future.

As the activities of the United Nations on peacetime uses of outer space increase, there will be correspondingly increasing demands upon NASA for participation and preparation.

> <u>Question:</u> How should NASA take an active role in preparation for international negotiations relating to space activities?

Ideally, very large space projects like planetary explorations should be truly world-supported endeavors, involving direct cooperation among the U.S., the U.S.S.R., and others.

> <u>Question:</u> However unlikely the attainment of this ideal of cooperation among the U.S., the U.S.S.R., and others may be, would a proposal along these lines by the United States have more political assets than liabilities?

VI. PUBLIC SERVICE AND COMMERCIAL APPLICATIONS

COMMUNICATION, NAVIGATION, AND METEOROLOGY

Satellites for communication, navigation and meteorology* are under active development for both military and civil purposes. They may ultimately have public service value or might even lead to direct commercial application for profit. In assessing the role of such space devices for public service purposes, cost comparisons with competitive systems may be more important than in military evaluations where other factors may predominate.

Programs of investigation are under way in NASA and industry to clarify the nature and extent of commercial applications of astronautics. Such studies are expressly stated as an objective of the Act (Subsection 102(c), Item (4)) and implicitly authorized for NASA.

Additional applications of a public service nature may flow from operation of observation satellites.** These would include aerial mapping, particularly of remote areas; geological surveys, identifying formation patterns; monitoring of river networks; forest-fire warning; snow surveys; iceberg patrol.

> Question: Are potential civil applications of space systems and technology being adequately investigated?

AMATEURS

The large body of hobbyists in fields relevant to astronautics are a very useful resource worthy of serious official attention. Radio amateurs have provided a good deal of useful data concerning signals from satellites

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*More detailed information on these satellite systems may be found in the Space Handbook, pp. 192-204.

**Space Handbook, pp. 171-191.

launched to date; and numerous non-professional astronomers have participated in the "Moonwatch" system for optical observation of satellites. These patient and often skilled observers can be of increasing usefulness if provided with proper information and a central data clearing house. In addition there are, as estimated by the American Rocket Society, about 10,000 amateur rocket experimenters--and 162 of them were injured in a recent six-month period. The enthusiastic interest behind these experiments could well be encouraged, but should also be the subject of a systematic effort to arrive at the intended result at a lower level of bodily hazard.

<u>Question</u>: To what extent should NASA provide for this segment of public interest?

ACCOUNTING AND CHARGING FOR ECONOMIC BENEFITS

Although it may not now be possible to fix a timetable for specific economic applications of space activity, it can be predicted with some confidence that they will occur, that they will begin within a few years, and that they will be substantial.

On the assumption that the economic benefits derived from space activities, and the differential cost of effort devoted to securing those benefits, are or will become partly expressible in dollar equivalents, the question is raised of accounting and charging appropriately for them. At least preliminary consideration could be given to several conceivable methods of handling the matter.

If the Federal Government conducts certain space activities that yield economic benefits and does not attempt to segregate the expense or impose a charge for use, the cost is in effect being defrayed by general revenues, principally from taxation. This may be regarded as tantamount to a subsidy in favor of the users at the expense of the non-users, if any. Such a method

may be considered appropriate if the benefits are believed to be incapable of arithmetic apportionment or if they are believed to be so widespread that allocation of charges would be unnecessary or inefficient.

Certain of the communications services now contemplated may lend themselves to specific charges for use, on the analogy of the Post Office; that analogy of course need not prejudge the question of whether the operation should be conducted in principle with the intention of turning a profit. Specific charges for use, however, imply the power of the public authority to monitor and control the conditions of use; some forms of space communication, which may as a technical matter be available without resort to government-controlled facilities on the ground, perhaps cannot yield revenue in the form of specific charges unless a reporting scheme, backed by enforceable sanctions, can be devised. If a passive reflector, launched for research purposes, can be used for signal relays by any one of an indefinite number of users within and without the United States, the government might give thought to the political desirability of publicly dedicating the reflector as an international free object, furnishing information on orbital elements and suggestions for optimum use.

In some economic applications of space, the Federal Government will be joined, assisted, and perhaps in time supplanted by private enterprise. Communications companies have expressed interest and begun to explore the possibilities of space relay and reflector systems. It will be necessary to arrive at government-industry agreements, probably concluded in several phases, apportioning research and development functions, costs, risks of failure and accident, and (ultimately) responsibility for operation, as well as monetary recovery from the public.

Consideration of some of the problems of this kind may be postponable. It should not, however, be restricted by reference to the present statutory limits of the jurisdiction of NASA. Once an economic benefit from a space activity is shown to be feasible as a result of research, development, and demonstration in operation, NASA's statutory mission as presently worded would seem to be discharged with respect to that particular application. Permanent operation of a space facility for commercially practicable use would seem to be outside NASA's present authority except to the extent that research and development problems are involved. Likewise, NASA's present authority would not seem to extend to the regulation of public-utility-type activities connected with outer space. Recommendation of legislation to lodge extensive operating authority or regulatory authority in some Federal Government organ, whether NASA or some other existing agency or a new agency, seems to be an appropriate subject for NASA's consideration at a proper time.

<u>Question</u>: What, if anything, should be done to encourage more active interest in commercial space systems by private enterprise?

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VII. WORLD-WIDE GROUND FACILITIES

To accomplish all planned space flight programs, it will be necessary to have world-wide facilities for launching, tracking, communication, computation and recovery.*

The following brief outline is intended to serve as a qualitative reminder of (a) the total magnitude of the national investment, (b) the overlapping nature of the civil and military requirements, and (c) the implications for international cooperation.

Actual costs and other detailed data concerning ground facilities should be obtained directly from the responsible agencies.

A joint DOD-NASA committee has made an inventory of all existing facilities, as well as of all military and NASA programs requiring facilities, to determine where gaps exist and to prevent duplication.

LAUNCHING AND TEST FACILITIES

At the present time major missile test facilities are located at:

- o Atlantic Missile Range (AFMTC, Patrick AFB)
- o Pacific Missile Range (Point Mugu, Vandenberg AFB)
- o Eglin Gulf Test Range (Tyndall AFB)
- o White Sands Missile Range (Holloman AFB)

None of these facilities as presently constituted can accommodate the larger launching rockets presently planned. Also, existing facilities could not accommodate large vehicles using nuclear propulsion or some chemical propellants because of contamination problems. Thus, the extensive modification of existing facilities and the establishment of new, remote facilities

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*See Space Handbook, pp. 138-139.

will probably be required, raising considerable problems in logistics and the acquisition of suitable real estate.

> <u>Question</u>: Should efforts to develop large chemical and nuclear rockets be supplemented now by arrangements for acquiring real estate for a large launching facility in a remote region?

<u>TRACKING FACILITIES</u>

The network of observation, tracking, and communication stations should eventually be adequate to permit continuous contact with vehicles from the time of launch.*

The following is a summary of present tracking facilities, including certain of the planned expansions:

MOONWATCH STATIONS

Location	Number	Location	Number
United States	42	Canada	1
Union of South Africa	12	Philippine Islands	1
Germany	7	Taiwan	1
Japan	88	Australia	3
Wake Island	1	Guatemala	1
Guam	1		

These stations lie between latitudes 52.5° North and 35° South.

To accommodate vehicles using polar orbits or orbits inclined more than 50° to the equator, additional Moonwatch stations closer to the polar regions would be required.

Of all the tracking facilities, these stations are the simplest to equip and operate. Equipment is usually no more elaborate than a small satellite

*<u>Space Handbook</u>, pp. 74-76, 8

tracking telescope and a radio receiver tuned to a time standard. The station can be operated by two people.

Baker-Nunn Facilities

The mainstay of the long-range optical tracking program is a world-wide network of precision photographic stations which use Baker-Nunn cameras.

There are twelve Baker-Nunn stations between latitudes 45° North and 30° South, located at:

- White Sands, New Mexico
- Woomera, Australia
- Cadiz, Spain
- Nitaka, Japan
- Naini-Tal, India
- Olifantsfontein, South Africa
- Shioag, Iran
- Curacao, Netherlands West Indies
- Palm Beach, Florida
- Villa Dolores, Argentina
- Haleakola, Hawaii
- Arequipa, Peru

The precise photographic reduction takes place at Cambridge, Mass., where special precision measuring devices are used.

As in the case of the Moonwatch stations, this network will require expansion to track vehicles on near-polar orbits.

Minitrack Stations

These radio tracking stations were set up as a part of the Vanguard Satellite Project.

At present there are twelve stations between latitudes 38.5° North and 34° South, located at:

- Antigua, British West Indies
- Mayaguana Island
- Grand Turk Island
- San Diego, California
- Blossom Point, Maryland
- Ft. Stewart, Georgia
- Batista Field, Havana, Cuba
- Quito, Ecuador
- Lima, Peru
- Antofagasta, Chile
- Santiago, Chile
- Woomera, Australia

Present plans call for establishing additional stations in Alaska, Newfoundland, Spain, and the United States. A Minitrack station requires about 23 acres of level land.

Deep-Space Stations

In order to perform continuous tracking of an interplanetary vehicle, at least three suitably located tracking facilities will be required.

At the present time the tracking facility at Goldstone is the only one in the U.S. which is adequate for tracking deep-space probes. The tracker consists of a movable antenna 85 feet in diameter and sensitive receivers for tracking signals transmitted by a space vehicle.

Present NASA plans call for two new facilities, located in South Africa and Australia.

COMMUNICATION FACILITIES

To accomplish various space missions involving both manned and unmanned vehicles on many different trajectories, it will be necessary to have adequate systems for communication between the space vehicle and ground stations, between ground stations, and between the ground stations and control or computation centers.

To obtain continuous communication for Project Mercury it will be necessary to use shipboard stations in the Pacific and Indian Oceans, as well as land stations.

COMPUTATIONAL FACILITIES

The information obtained from each network mentioned must be processed by one or more computers, and any new launching or tracking facility will require access to a suitable computation center.*

*Space Handbook, pp. 82-83.

Computer facilities generally require air conditioning, special power supplies, dust-free and moisture-free housing, fairly elaborate checkout and maintenance equipment, and a considerable body of trained personnel.

RECOVERY FACILITIES

Every space flight program involving manned vehicles, or vehicles carrying packages that are to be returned to the earth's surface, will require recovery facilities.

For manned systems, the recovery plans and equipment will necessarily be quite elaborate in order to insure adequate safety. The recovery equipment will generally involve ships, aircraft and considerable manpower.

Question: Is the program for construction and operation of ground facilities in proper balance with the military and non-military program for development and operation of vehicles?

Question: What part of the costs for construction and operation of ground facilities can be properly charged to the non-military part of the national space program?

VIII. VEHICLES

LAUNCHING VEHICLES

The nation's astronautics assets in vehicles are, at present, chiefly the products of military programs.

Vehicle developments fall into four general categories:

1. Minor modification of items already developed in military programs (e.g., WS-117L).
2. Extension, by supplementary development, of capabilities of basic items from military programs (e.g., Atlas/Vega).
3. New developments based on use of components developed by the military (e.g., Saturn).
4. Essentially new developments (e.g., Nova).

> Question: How much effort should be applied to presently understood launching-vehicle development possibilities in these categories to serve the objectives and needs of the national space program?

The general trend of possibilities is indicated in Table 1 and Fig. 1. Since all of the payload figures and first-flight-test dates may not correspond exactly to the latest official planning, the responsible agencies should be consulted for confirmation, revision, or fuller discussion of these details. Cost figures and other program details are also best obtained from the agencies and contractors concerned.

The capabilities of the various vehicles have been summarized in Table 1 with reference to a standard capability--that of placing a satellite payload on orbit 300 miles above the earth's surface. This standard capability is related to other interesting payload figures for a given rocket assembly by the curve of Fig. 2.

Table 1

SUMMARY OF SPACE VEHICLE CAPABILITIES

Vehicle Name	Summary Description	Reference Payload Capability for 300-mi Orbit (lb)	First-Flight Date[a]	Remarks
Vanguard	3-stage satellite vehicle designed for I.G.Y.	20-50	12/6/57 3/17/58	First test. First orbit.
Jupiter C	4-stage vehicle: modified Redstone booster and 3 stages of small solid rockets	20	3/-/56 1/31/58	First flight as ballistic missile. First U.S. satellite (Explorer series).
Juno II	4-stage vehicle: modified Jupiter IRBM and 3 stages of small solid rockets	100	12/6/58	Pioneer III.
Thor/Able	2-stage vehicle: Thor IRBM booster and Vanguard second stage	200	4/-/58 10/11/58	First flight as ballistic missile. First flight as Pioneer I (with added stage of solid propellant).
Thor/Hustler	2-stage vehicle: Thor IRBM and Hustler (WS-117L) stage	400	2/28/59	First flight as Discoverer I with 245-lb payload.
Thor/Delta	3-stage vehicle designed for lunar and space probe: Thor/Able and third stage (similar to Pioneer I)	500	Early 1960	Extension of Thor/Able program.
Atlas	1-1/2-stage ICBM modified for SCORE satellite and Mercury booster	150	12/18/58	Orbit--Project SCORE.

(Cont'd.)

Table 1 (Cont'd.)

Vehicle Name	Summary Description	Reference Payload Capability for 300-mi Orbit (lb)	First-Flight Date[a]	Remarks
Atlas/Able	Atlas 1-1/2-stage booster combined with Vanguard second stage	2200	6/-/59	Scheduled date cancelled. Designed as space probe with 50-lb payload.
Atlas/Hustler	Atlas 1-1/2-stage booster with Hustler (WS-117L) upper stage	3100	Late 1959-Early 1960	Combination selected for WS-117L satellite.
Atlas/Vega	Atlas booster combined with new development using Vanguard first-stage engine (Atlas is modified to accept 10-ft-diameter upper stage)	5000	Fall 1960	Schedule date.
Atlas/Centaur	Modified Atlas (as above) combined with high-energy Centaur stage (lox-hydrogen)	8000	Mid-1961	Schedule date.
Saturn	Clustered tanks and engine assy. forming first stage (8 188,000-lb-thrust engines with 1 Jupiter tank and 8 Redstone tanks) combined with modified ICBM as upper stages	19,000	Mid-1962	Planned date (ARPA development).
Advanced Saturn	As above with high-energy upper stage	30,000	Mid-1963	Estimated date (not programmed).

(Cont'd.)

Table 1 (Cont'd.)

Vehicle Name	Summary Description	Reference Payload Capability for 300-mi Orbit (lb)	First-Flight Date[a]	Remarks
Nova	Clustered 1,500,000-lb-thrust engines (no air-frame design)	150,000	Mid-1965	Planned date (engine development program--ARPA).
Scout	4-stage solid-propellant missile using modifications of Polaris-Sergeant-Vanguard II motor developments	150	Early 1960	
[illegible] X	2-stage Titan plus small third stage	3000	Early 1960	Estimated.
Advanced Titan X	2-stage modified Titan plus small third stage	8000	1963	Estimated.
Clustered Atlas	3-stage vehicle: 3 Atlas (clustered) plus Atlas and Centaur	31,000	1964	Estimated.
Clustered Titan	4-stage vehicle: 4 Titan I (clustered) plus Titan I, Titan II, and Centaur	33,500	1964-1965	Estimated.
Clustered Thor	4-stage vehicle: 7 Thor (clustered) plus Titan I, Titan II, and Centaur	29,500	1964	Estimated.

[a]Dates when system functions reliably may be well beyond scheduled first-flight dates.

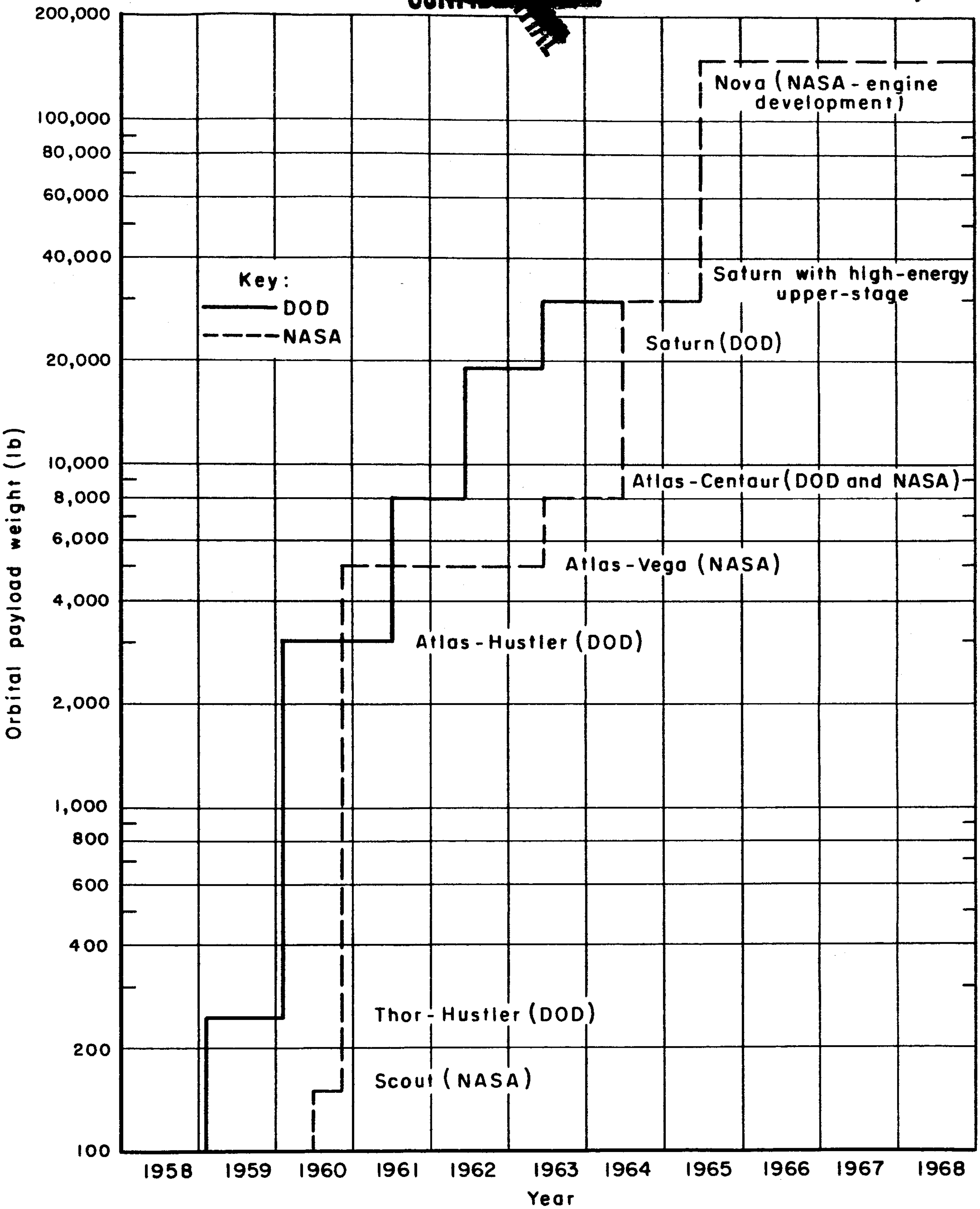

Fig. 1 — U.S. planned space capability
(based on 300-mile orbit)

[redacted]

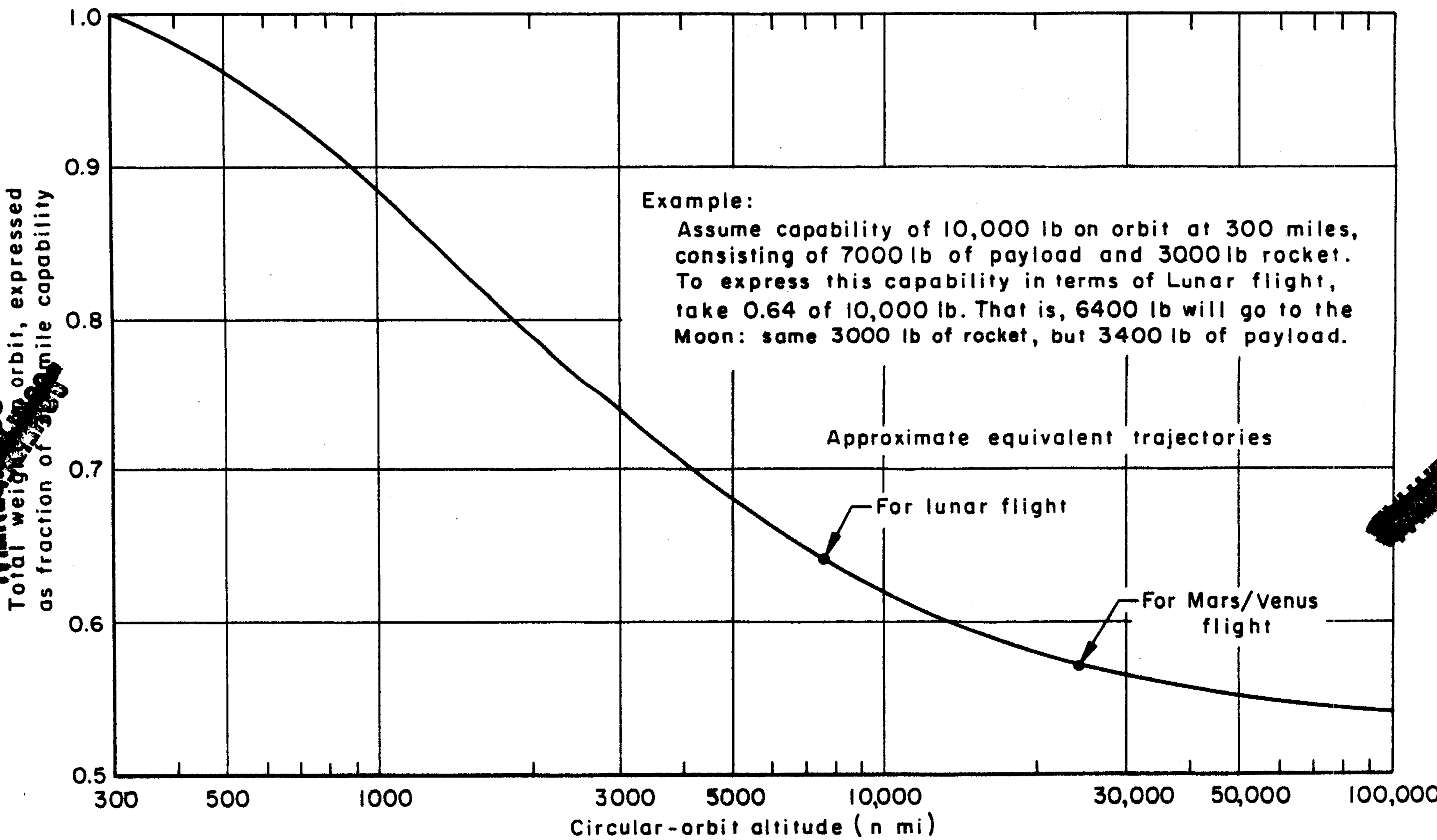

Fig. 2 — Conversion chart for space vehicles

[redacted]

It should be carefully noted that the dates listed on Table 1 are dates on which a first flight test is scheduled. The time when a system can be said to function with reasonable reliability may be--and commonly is--well beyond this first test date.

The number of flight test vehicles required to bring a system to operational readiness is a highly variable and indefinite matter, as the data in Table 2 indicate.

PAYLOAD CARRIERS

In addition to the launching vehicles there are others that actually house the payloads; these are literally space vehicles.

The payload carriers for Explorer and Vanguard cost comparatively little, although they required a long time for development. But the payload carriers for Sputnik III and for Discoverer represent major undertakings.

Several programs now in development involve large, complex, and expensive payload carriers: specifically, Project WS-117L (Reconnaissance Satellite), Dyna-Soar (Manned Aerospace Global Glider), and Project Mercury (Manned Satellite). These programs, which represent heavy national investments, require not only that the space vehicle be large, but also that it include complete provisions for such items as internal power, control of environment and orientation, and communication.

These three programs portend the larger space vehicles that will have to be developed for use with the large launching rockets currently programmed. It seems quite likely that the time and money required to develop and produce the larger payload carriers (particularly manned vehicles) will be comparable with the time and money required to develop and produce the launching rockets.

Table 2

SUMMARY OF U.S. MISSILE FIRINGS (R AND D)

Successful firings expressed as cumulative totals

Flight Number	Single-Stage Missiles					Multistage Missiles				
	Redstone	Thor	Jupiter	Atlas	Titan	Atlas (2 Stages)	Thor-Able (2 Stages)	Thor-Hustler (2 Stages)	Vanguard (3 Stages)	Explorer-Jupiter C (4 Stages)
1	1	0	0	0	1	0	0	1	0	1
2	2	0	0	0	2	1	1	2	0	2
3	2	0	1	1	3	2	2	2	1	2
4	3	0	2	2	4	3	2	2	1	3
5	4	1	3	2		3	3		1	4
6	5	1	3	2		4	4		1	4
7	6	1	3	2		5	5		1	4
8	7	2	4	3		6	6		2	
9	7	2	5			7	7		2	
10	7	3	6			7			2	
11	8	3	6			8				
12	9	3	7			9				
13	10	3	8			9				
14	11	4	9			9				
15	12	5	10			9				
16	13	6	11			9				
17	14	6	12			9				
18	14	6	13							
19	15	6	14							
20	16[a]	7[a]	15							
Score[b]	34/42	19/33	15/20	3/8	4/4	9/17	7/9	2/4	2/10	4/7

[a]Column incomplete.
[b]Successes/attempts as of June, 1959.

Of course, the large-payload-carrier development program must be accompanied by a program of research to define projected space missions and determine the nature and characteristics of the payloads by which they may be accomplished. This research, and the subsequent design and testing of payload equipment, may require long periods of time.

<u>Question</u>: Is proper emphasis being placed on development of payloads and payload carriers for use with the large launching rockets now in development?

IX. SOURCES OF INFORMATION

It is suggested that reference be made to National Aeronautics and Space Act of 1958, Conference Report No. 2166, House of Representatives, 85th Congress, 2nd Session, July 15, 1958, as a summary of the Act establishing NASA, and a brief outline of the apparent intent of the Congress in this Act.

While many documents are available concerning the technical aspects of astronautics, use has been made in this report of a single source: Space Handbook: Astronautics and Its Applications, Staff Report of the Select Committee on Astronautics and Space Exploration, 85th Congress, 2nd Session, 1959, as a basic unified reference.

In addition to the NASA staff, the following sources of detailed information on the various areas of interest are suggested. It should be emphasized that this list is by no means exhaustive.

Source	Type of Information
Department of Defense	
1. Director, Defense Research and Engineering	Relations of military research and development in space technology to the general research and engineering program of the Department of Defense
2. Director, Advanced Research Projects Agency	General summary of military space programs and plans
3. Chairman, Civilian-Military Liaison Committee	Operation of the C-MLC
4. Joint Advance Study Group, Joint Staff, Joint Chiefs of Staff	Future military operations in space
5. Department of the Army	Army plans and interest in space activities
6. Department of the Navy	Navy plans and activities

7.	Department of the Air Force	Air Force plans and interest in space activities
8.	Commander, Air Research and Development Command	Dyna-Soar Program
9.	Commander, Air Force Ballistic Missile Division, Air Research and Development Command	Air Force ballistic missile and space activities; reconnaissance satellite project WS-117L
10.	Director, Development Operations Division, Army Ballistic Missile Agency	Requirements for engineering test and evaluation in space; Army ballistic missile and space activities
11.	Commander, Pacific Missile Range	Launching facilities and operations
12.	Commander, Atlantic Missile Range	Launching facilities and operations
13.	Air Force Special Weapons Center	Facilities requirements for nuclear rockets
14.	Naval Research Laboratory	Navigation satellites
15.	Chief of Engineers, Army Corps of Engineers	Value of satellite observations to river monitoring

<u>Department of State</u>

1.	Office of the Special Assistant to the Secretary for Disarmament and Atomic Energy	Development of international agreements on control and operation
2.	Office of Political Affairs, Bureau of United Nations Affairs	U.S. participations in, and commitments to, United Nations space proceedings

<u>Department of Commerce</u>

1.	Director of Research, United States Weather Bureau	Meteorological satellites; economic aspects of weather forecasting
2.	Director, U.S. Coast and Geodetic Survey	Value of satellite observations to aerial mapping and geodetic surveys

<u>Department of Agriculture</u>

1.	Chief Forester, U.S. Forest Service	Value of satellite observations to forest-fire monitoring

Department of the Interior

1. U.S. Geological Survey	Value of satellite observations to geological surveys

Treasury Department

1. Headquarters, U.S. Coast Guard	Value of satellite observations to iceberg patrol

Central Intelligence Agency

1. Assistant Director for Scientific Intelligence	USSR space activities, capabilities, plans, and organization

Atomic Energy Commission

1. Director, Los Alamos Scientific Laboratory	Use of space vehicles for monitoring nuclear weapon tests in space; nuclear rockets - Rover program

United States Information Agency

1. Office of Research and Intelligence	Apparent public attitudes toward space activities

National Science Foundation

1. Director, National Science Foundation	Possibilities and problems of scientific research in space; avenues for international collaboration in space sciences

National Academy of Sciences

1. President, National Academy of Sciences	Possibilities and problems of scientific research in space; avenues for international collaboration in space sciences
2. Chairman, United States National Committee for the International Geophysical Year	International cooperation in large scientific enterprises
3. Chairman, Space Sciences Board	Space sciences program

Industry and Other Institutions

1. Director, Jet Propulsion Laboratory, California Institute of Technology	Status of space technology and prime needs for advancement

2.	Executive Vice President, Space Technology Laboratories	Status of space technology and prime needs for advancement
3.	Manager, Astronautics Division, Convair Division of General Dynamics Corporation	Atlas ballistic missile and its potential for space applications
4.	Vice President and General Manager, Denver Division, The Martin Company	Titan ballistic missile and its potential for space applications
5.	Vice President - Missiles, Douglas Aircraft Company	Thor ballistic missile and its potential for space applications
6.	General Manager, Missile Division, Chrysler Corporation	Jupiter ballistic missile and its potential for space applications
7.	Vice President and General Manager, Missiles and Space Division, Lockheed Aircraft Corporation	Reconnaissance satellite project WS-117L and its potential for further space applications
8.	Vice President and General Manager, Rocketdyne Division, North American Aviation, Inc.	Large rocket engine status
9.	Vice Presidents, Liquid and Solid Rocket Divisions, Aerojet-General Corporation	Large rocket engine status
10.	American Telephone and Telegraph Company	Commercial applications of communication satellites

MEMORANDUM ON THE NEED FOR A STUDY TO DEVELOP A SUPPORTABLE POSITION ON RATE AND SCALE IN SPACE RESEARCH

(from T. Keith Glennan, June 19, 1959)

The Problem

To identify national objectives to be served by a program of non-military space activities, to suggest the magnitude and scope of the program required to attain those objectives, and to determine the balance of emphasis to be placed on various phases of the program in both the short and long term future.

Background Information

The following statements are believed to reflect the conditions that presently exist as a background against which NASA is attempting to develop and carry out the national program of non-military space activities:

a. While the military departments have had an interest in the use of the space environment for several years, public and governmental acceptance of this field of research and application is of very recent origin and of questionable depth. Indeed, that acceptance was born in a semi-hysterical response to the accomplishments of the USSR in this field--not from the conviction that this new frontier presented a challenge and an opportunity for useful and beneficial human activity.

b. We are becoming increasingly conscious of the enormous technical difficulties that face us in this field. It is apparent that very large sums of money and substantial numbers of highly trained research and development people would be required to make maximum or even substantial progress in the next decade in <u>each</u> promising area. To achieve such progress would require a diversion of resources of such magnitude as to constitute a crash effort. And yet, in the non-military areas, it is not clear that a crash program is warranted or, indeed, would be substantially more productive than a well-planned, orderly and determined approach to the solution of the problems that face us.

c. Inputs to the presently delineated program in NASA have come mainly from the Space Science Board of the National Academy and from our own groups. Much has been accomplished because of the impetus given to the program by enthusiastic scientists seeking new and exciting fields to conquer. But the realities of budgetary restrictions and problems of organizational development and the housing of people and activities suggest a more comprehensive approach. The sheer magnitude of the impact of space programs on the budget makes the space effort a matter of public policy which deserves and requires the attention of top flight non-scientific thinking.

d. Rational planning and implementation of an orderly program for the development of the devices and facilities (booster and vehicular systems, tracking nets, launch and range facilities) which must undergird any on-going program is proving to be both expensive and time consuming. As a result, it has been necessary to slow down the undertaking of research in space to such an extent that we face the prospect of losing the enthusiasm that must be present if progress is to be made.

e. Facilities for these programs, including launching, tracking, data acquisition, and R & D facilities must be world-wide in extent and will be expensive to build, to maintain and operate. A minimum level of research effort would seem to be required to justify the investment in money and management necessary to provide these facilities.

Discussion

The Department of Defense has adopted and is pursuing a course which recognizes space as merely one additional environment in which to utilize devices and systems to accomplish one or more military objectives. From a military standpoint, this viewpoint would seem to have merit. Pursued to its logical conclusion, space activities in the Department of Defense would then compete for money with other methods of accomplishing military objectives.

The NASA has been given broad responsibility for research, development, and exploration in aeronautics and space. Reserved to the DOD are those activities which are "peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States)." The parenthetical clause appears to permit research and development by the DOD in almost any area of its choosing, and thus it is probably not feasible to attempt to fix a hard and fast line between the research and development activities of NASA and DOD in the space field. Establishment of "military requirements" sets a degree of urgency that may or may not be realistic but which strongly affects the method of attack and the rate at which progress is attempted.

The end objectives of the NASA program, much of which will support military objectives in space, have less popular and Congressional appeal than most of the military programs. And yet, it appears that a vigorous civilian program must quickly move to a budgetary level of more than one billion dollars annually. What then is or what should be the level of effort applied by NASA and what is the rationale that will support such a level, whatever it may be?

It seems clear that we now have enough experience to examine more adequately the economic, sociological, and political aspects of space activities and that the probable course of scientific activity can be more sensibly predicted than was the case eighteen months ago. Accordingly, it should be possible to develop a rationale that could be supported by the Administration and the Congress and on which there could be developed a sound and well balanced

program of non-military space activities. It should also be possible to discover a better method for determining the relationship of NASA's efforts to those of DOD than presently exists.